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ABSTRACT

This paper is designed to provide the educator with an overview of instructional applications of the computer, along with important issues related to each application. Applications discussed include computer managed instruction, drill and practice, simulation, computer assisted testing, instructional games, tutorials, problem solving, and classroom management. Some ways that teachers have started bringing computers into their schools are listed, as well as two references. This is one of a series of monographs prepared as resources for the preservice and inservice training of teachers. (CHV)

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Number 2e

The Illinois Series on Educational Application Of Computers

A TEACHER'S INTRODUCTION TO EDUCATIONAL COMPUTING

J. Richard Dennis

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To the reader,

This is one of a series of documents prepared as resources for the preservice and inservice training of teachers. The general theme of all items in this series is "teaching with or about computers". The booklets are the collective work of a variety of staff and students (both present and former) of the College of Education, University of Illinois at Urbana-Champaign. The project generously was supported between 1977 and 1979 by a grant from the EXXON Education Foundation. All resposibility for the content of these documents rests with the authors and does not reflect necessarily the views of the EXXON Foundation. It was my extreme pleasure to direct this effort throughout.

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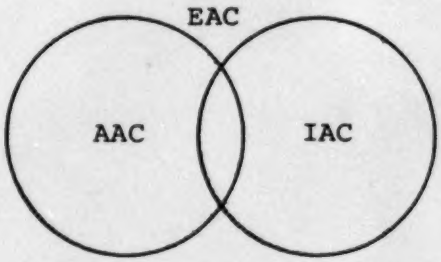
A TEACHER'S INTRODUCTION TO

EDUCATIONAL COMPUTING

Computers have become a reality in more and more schools during the past two decades. By 1975, Bukosky and Korotkin (1976) reported that 58.2% of the secondary schools in the United States were using computers and 26.7% of these same institutions were using computers in some manner for instructional activity.

This paper is the first in a special monograph series designed to provide preservice or inservice teachers with an understanding of the ways in which computers have been used to aid education. These materials also are designed to provide the teacher with a sound basis from which to choose intelligently and to evaluate applications of computers for use in their teaching activities.

To help us to categorize, to compare and to discuss various possible uses of computers in schooling, some terminology is needed. In this and subsequent papers, we shall refer to the universe of school computer uses as Educational Applications of Computers(EAC). This universe immediately separates into two subsets of activities: the Administrative Applications of Computers(AAC) and the Instructional Applications of Computers(IAC). These subsets are not mutually exclusive since a given use of computers may serve both an administrative function and an instructional one. Schematically, then, what we have is the following:



Our major purpose in this monograph is to assist the educator in obtaining an overview of instructional applications of computers. In a later paper in this series, (ISEAC No.15e), we shall present an overview of administrative applications of computers.

Although the field of educational computing has associated with it a large literature of techniques and research, knowledge of this literature by itself is not, in our opinion, an adequate background for a teacher to claim understanding of educational computing. Such a teacher also must have experienced and experimented with a variety of computer uses, both from the view point of the student and from the view point of the instructor.

Instructional Applications of Computers

In this section we briefly shall describe the variety of ways computers have been applied to instructional activities. Also for each of these, we shall describe briefly some of the important issues with which a teacher should be familiar. Few details will be included here. Rather, a more lengthy and informative discussion of each is the topic of a subsequent monograph of this series. For convenience, we shall reference the relevant papers at the appropriate times.

The realm of instructional applications of computers is comprised of two major parts. The first of these consists of all those activities whose primary goal is to teach about computers. These topics usually come under the heading Computer Science. The second major subset of IAC is composed of all those activities which involve teaching with a computer, that is, using the computer as a tool for instruction in some content. Of course, these subsets are not mutually exclusive since one can (and frequently may) use a computer somehow in the teaching of knowledge about computers.

Teaching about Computers

At precollege levels, the overwhelming majority of the activity with computers has been to teach about the computer. Most of this effort has gone into teaching students to make a computer do what it will do, that is, computer programming. Sometimes, precollege teachers instruct their students in detail on how a computer is designed and how one works. However, this usually is a small portion of their effort.

An activity growing in popularity in teaching about computers has come to be referred to as computer literacy. Essentially, when one speaks of computer literacy one is referring to content coming under a heading of "what every person should know about computers". At the present time, there are several views of what would constitute a computer literacy experience, but usually the following topics will be included:

1. Computer design and structure.

2. Uses of computers.

3. The citizen and computers--personal rights, laws, and privacy issues involving computers.

4. How do humans control computers--An introductory programming experience.

In addition to general computer literacy there are three other common goals of teaching about computers. The first of these is the "preparation for college" objective prevalent in many other schooling activities. More and more undergraduate programs are including a basic understanding of computers and their uses in that field as a requirement for a degree. Precollege school personnel argue for teaching about computers as a means of accelerating their students when they reach college.

The second goal of teaching about computers, and one much less frequently articulated, is that of career education. Specifically, we refer to the goal of teaching entry level job skills in some aspect of computing. This goal clearly is within the means of precollege programs. It is not uncommon among high schools already having multiple course experiences in computing to have students take summer jobs or post-graduation positions as computer programmers.

The third major justification for teaching about computers is that knowledge of computers provides important new learning skills to gain access to knowledge in a variety of other fields. The computer can be used to assist in gathering, organizing, and analyzing data in the solution of problems.

There are two common methods of using a computer in teaching. These are referred to as batch style computing and interactive style computing. Batch style computer use usually is done with computer readable cards (the famous "IBM cards"). Programs are written on such cards either by using a key-punch machine to punch holes in the card to represent each letter or number, or by marking boxes on a computer card with a dark pencil to represent each letter or number. In most schools, the pencil marking of cards is preferred for batch style programming since it does not require additional expense for card punching equipment. Once a student program is recorded on the cards, it is presented to the computer for execution through a card reading device and the various results of the exection are reported via some kind of printing device.

For interactive style programming, a student creates his program by typing it on a keyboard of some form. Usually, this keyboard resembles a typewriter keyboard, perhaps with extra special purpose keys added. The student sees what he is typing either on a piece of paper or on a display resembling a television screen. Once a program is constructed the student uses the keyboard to instruct the computer to execute his program. When it does so, the result of the execution is shown on the paper or screen device.

Interactive style programming gives the student more immediate results and usually makes for more efficient correction of errors in programming. However, it requires much more investment in equipment to permit such activity by large numbers of students since each student involved in a programming exercise ties up one keyboard-screen facility (called a terminal) for his work. An exercise requiring an average of one-half hour to complete will require (1/2 times the number of students) hours of available terminal devices. This tends to force compromise either in terms of the number of students that can enroll in such courses at a given time or in terms of the number of such activities each student may be permitted to attempt. The batch style programming method, although less immediate, can handle much larger student loads with much less equipment since usually only one or two minutes of the average 30 minute exercise actually requires the computer.

Some computer "experts" may argue that batch style programming is an inferior experience for students. These arguments are matters of style and taste. The immediacy and efficiency of interactive computing is to be preferred. However, for a school trying to make knowledge available to as many students as wish that knowledge, compromises on style or taste frequently must be considered.

Teaching With Computers

Whenever a computer becomes a medium for an instructional activity, we say we are teaching with the computer. Also, teaching about computers usually is an instance of teaching with a computer since few teachers would entertain instruction in programming or other aspects of computing without the aid of some type of computer.

Following are several styles in which a computer may be used to facilitate instruction or other activities:

1. Computer Managed Instruction(CMI)
2. Drill and Practice
3. Simulation
4. Computer Assisted Testing
5. Instructional Games
6. Tutorials
7. Problem Solving
8. Classroom Management

Below we briefly describe each of these, together with some of the types of knowledge a teacher needs in order effectively to utilize a computer in that style. Subsequent papers of this series are designed to provide the teacher with a detailed view of each of these instructional computing uses. A full understanding of each use, and how the teacher or instruction is aided by it, also depends in large measure on "hands-on" experiences with instances of that use.

Computer Managed Instruction (CMI)

In this style of instructional computing, the role of the computer is to control and to expedite the "traffic" during instruction. In doing this, the computer assumes responsibility for tasks such as: diagnosing, assigning, routing through the curriculum, communication among members of the instructional setting, controlling and maximizing utilization of resourses (such as time, equipment, instructional personnel, etc.), progress evaluation and related record keeping.

Initial instruction may not be the responsibility of the computer in this style. The teacher may still do group lessons and discussions, and may still do individual tutoring, but usually determination of the need for such events, the scheduling of them, and the transmission of information to involved persons is done by the computer. Generally, what the computer tries to do in CMI is to keep each person in the instructional setting as productive as possible during a maximum portion of the time that the person chooses to devote to the instructional tasks.

The operations performed by a CMI system essentially are those needed to individualize instruction. This should not be construed, however, to mean that the teacher never works with groups nor gives instructional lectures. The difference is that in a good CMI system these group events happen more on the basis of some identified need than on a regular schedule as found in group settings. A group of students is determined to be ready for an introduction or discussion on topic X, so the computer schedules it and announces same to the involved persons.

What a teacher needs most in order to implement CMI in a course are:

1. A clearly defined curricular progression, including specification of points at which individual decisions must be made and the conditions for making each of them.

2. A well developed CMI control program, in which to embed the details of the curricular progression and all related decisions.

Several CMI systems have been developed and refined in recent years. Details of these, and a much more detailed discussion of CMI can be found in a later paper of this series (ISEAC No.11e). Another paper of the series (ISEAC No.23e) contains documentation and programs for one CMI control system called CAISP (Computer Assisted Individual Study Program). This system could be used by teachers attempting to implement CMI in courses for which existing materials are not available.

Drill And Practice

One of the early instructional activities to be computerized was that of repeatedly exercising students to help them learn. This is the activity involved in the homework assignments of many teachers or in the exercise sets of many textbooks. An argument that was used to justify such activity was that a computer could be programmed not only to present exercises, but also to check the student's answer immediately and to give some sort of response based upon the correctness of the answer. Textbooks are unable to provide such services to students for, although correct answers can be printed, say, in the back of the book, it is difficult in text form to give responses or corrective messages to a wide variety of incorrect answers. In theory at least, this can be done with a computer. The computer can provide as many corrective messages to as many different incorrect responses as the creator of the drill and practice lesson can invent or as experience can provide.

This dependence upon the creativity of computer lesson writers turned out to be a severe detriment to early drill and practice efforts. In fact, some would argue that inadequacy of early efforts of this kind seriously may have delayed the development of instructional computing. Whether or not this is true is a matter for historians. What is important now is to know that through experience, and by following a few basic principles about the design of practice, one can create computerized practice materials that greatly optimize a student's practice efforts.

In a later paper of this series (ISEAC No.7e) we shall discuss drill and practice design principles in greater detail. Some of these principles are as follows:

1. A correct answer to an exercise has only a small probaibilty of indicating learning.

2. Several correct responses to an exercise, spread over time, increase the probability that learning has occurred.

3. Correct responses over time to a set of related but different exercises on a topic increase still more the probability that learning has taken place, rather than that a correct response has been memorized.

4. When incorrect responses are made, the student requires some form of corrective intervention. The more specific the intervention is to the misconception causing the incorrect response, the more helpful it is to the student.

5. Variations of exercises on which errors occur need thereafter to be presented more often than those on which there regularly is success.

When these and other principles of design for computerized practice are followed, many of the annoying features found in early attempts of this kind will disappear and the student will be provided with a helpful, motivating experience. It is the task of the teacher to know what constitutes well-designed practice materials and to accept nothing less.

Simulation

In many situations in our universe a phenomenon exists which is characterized by a task to be completed, a goal to be reached, or an environment to be understood. Frequently, completing the task, reaching the goal, or achieving the understanding requires correct executuion of a variety of decisions, or correct interpretation of a variety of data. Many such phenomena about which we might wish to learn involve a degree of risk or jeopardy of some form during the learning process. Some examples of such situations are learning to fly an airplane, learning to perform particular (perhaps dangerous) laboratory procedures, learning to understand and to control various social or physical phenomenon such as environmental polution or population growth, learning to diagnose diseases, and learning to manage a business.

Of course, we have textbooks for all these situations which describe the principles of behavior of each phenomenon. However, when the desired learning includes a demonstration of acquired performance, in addition to acquired text knowledge, some means is needed conveniently of helping the learner from the text knowledge to effective performance. Apprenticeships, carefully supervised by professionals, are one such means. However, these greatly can increase the costs of education and limit the audience to which such learning can be made available.

What is needed in such situations is a recreation of key parts of the actual environment to permit students to have surrogate experiences without the necessity of the real consequences of misjudgements. Such a recreation is a simulation. The extent to which a simulation causes the learner to identify with the situation, or to view his actions as real, is called the fidelity of the simulation. Not all simulations created to date require a computer. Many simulations have been created in paper-and-pencil form and many have been created in the form of a board game. Role playing by individuals is another form of simulation.

In schools, simulations can make environments available to students that might not be accessible otherwise due to extreme expense, safety factors, or the time required actually to experience important consequences. A type of simulation particularly popular in schools is that which replicates various laboratory procedures or experiments (acid/base titrations, identification of unknowns, breeding of organisms, etc.) or that which permits experimentation with physical phenomena not easily available in the real world environment (execution of lunar landings, control of water polution, etc.).

Simulations (whether or not computerized) are expensive and difficult to build. In use, simulations tend to encourage multiple experiences by students. This aspect greatly can increase classroom management problems each time a simulation is used. Educators just are beginning to understand what simulations do in learning situations and how they do it. Several have suggested that learning derived from simulation is different from that derived by other means. Consistently to date, studies of simulation have demonstrated good learner attitudes about the experiences. However, much more research will be needed to determine whether learning via simulation is different from that derived other ways, and the nature of such differences.

The instructional computing teacher needs to spend time studying simulations to learn what they are, the contents and systematic process of their construction, and the various means of using simulations in the classroom. A detailed discussion of these important points is found in ISEAC No.8e.

Computer Assisted Testing

Testing is one of the major activities of the teacher. Although not one of the early instructional actities to be attempted by computers, testing and evaluation in recent years have become one of the rapidly growing styles of computer activity in education. Several schemes are found for using computers in this sector of education including computerized test grading, computer test construction, computer test item banking, computer test attribute banking, test item generation, etc.

Computerized test grading usually involves multiple choice or simple constructed response test items. The grading of sentence responses and of essay type responses is a task only partialy within the means of instructional computer technology. In its simplest form, computerized grading provides checking of correct and incorrect answers, and tallying of scores of the students and the class. More sophisticated systems also include an array of statistical analyses of the students, the test, and the individual items. For the student these might include a listing of incorrect responses together with the correct answer, a raw score, a percentage score, a class rank, etc. For the test one might be provided a frequency distribution of the student scores, an estimate of the test reliability, as well as the more common mean, median, and standard deviation scores. For individual test items, one might be provided with estimates of the item difficulyt, the relative performance of the alternative choices (the distractors), and an estimate of the item's discrimination ability.

Providing a teacher with lists of test or item statistics is of slight value if the teacher has little time or experience at interpreting the results and acting on the interpretation. Still more sophisticated test grading systems will provide these interpretations wherever they are predictable. Telling the teacher when an item, or an alternative may be ambiguous, has a different difficulty than expected, or for some other reason needs rewriting is a service that saves time and encourages the teacher systematically to improve test efforts.

Computer test item banking is a scheme in which the computer stores, categorizes, and assists in the retrieval of test items, Such services have been pioneered by commercial testing services for standardized testing, and are finding increasing application in the more dense instructional settings (universities, large shools, or large departments). Briefly, in this style the computer stores each question and a variety of information about it (the objective it tests, its difficulty, the correct answers, etc.). In larger systems, several items will be stored for each objective, giving a range or variety over the other attributes. The computer then has a process (perhaps interactive, or perhaps batch) that permits the teacher to specify the objectives a test

is to measure, the number of items to include for each, the item difficulties, etc. Some item banking systems provide the teacher with an opportunity to view and to accept or reject the items selected by the computer. Once approved, the test is produced by the computer, perhaps on a reproducible form. More sophisticated systems would permit the teacher a variety of options for formatting the test or equivalent forms.

A computerized test attribute banking system can be viewed as a subset of a test item banking system. In this case only the attributes are in the computer. For teacher-given specifications, identifying codes for appropriate items are listed. The teacher goes to a card file, a catalogue, or other external medium to view and to retrieve the actual items. This style system usually would not provide test printing or formatting capabilities. On the other hand, however, attribute banks are within the means of smaller computers due to the smaller storage requirements.

Sometimes a test grading system is coupled to an item or attribute banking system. In the better instances of such marriages, not only does the computer provide an array of grading services, but the item attributes are revised and updated each time the item is used on a test.

A test item generating system may also be coupled to the other computerized testing features to provide much richer varieties of test items. In this mode, the computer houses item forms (or templates). Each template is used to generate as many items with as many variations as are built into the item pattern. Each template usually is associated with a single objective.

For use in schools, computer test grading and test analysis systems are the most readily implemented. (Documentation of such a system is included in ISEAC No.12e.) For test construction or item banking systems, the teacher either must buy the items in the bank, or have written them. This can be efficient if several teachers of a course pool their test items. Optimal use of computerized testing systems requires considerable knowledge on the part of the teacher, about computers (e.g. selecting storage devices large enough to do the job), about testing and item construction, and some about computer software (e.g., the options and attributes of good computer testing programs).

Instructional Games

Play has long been an important mode of learning for humans. In play, a person usually is motivated, is kept active on a task, and the task changes as a result of his/her individual characteristics. These are all attributes of learning settings long favored by educators. As students increase in age, however, play as a mode of intellectual learning becomes less noticable in

schools. Partly, this may be due to adult feelings that as one grows older, learning should become more like work, in which fun is replaced by, at best, "serious enjoyment" or detached satisfaction.

One of the challenging uses of computers has been in attempts to make one capable of participating in a variety of games. These frequently find disfavor in schools because it is difficult to identify (and to relate to the school curriculm) specifically what is being learned. To be sure, as a result of many experiences with, say, a STAR WARS game, students' behaviors do change. But how those changes are productive to the objectives of schooling sometimes is difficult to say.

A game is an activity involving individual decision and a competition over some limited commodity. When the performances of play involve acquisition of behaviors related to school objectives we call them "instructional games". Many such games have been computerized. Some such efforts have included creation of a process permitting the computer to adjust its own play ability to that of the students. Computerized simulations have been turned into games (called simulation games) by adding competition to the decision activities of the user.

Tutorials

Instructional computing in the tutorial style is an attempt to give the computer total responsibility for teaching. Tutorial computer lessons, in a sense, are simulations of the best teaching behavior to a high level of fidelity. Usually we can recognize very good teaching in contrast to very bad. Identifying all the ingredients and particularly the decisions of such acts to render them for computer replication is a monumental task. To do so, one must become acutely aware of what is done, when, why, and for whom in an instructional episode. Usually, not all of these variables are clearly, or uniquely defined. To date, attempts at tutorial style computer instruction have been very few in number, very narrow in topic context, and very limited in their success.

Problem Solving

There are at least two ways that computers are used to aid in problem solving activity. These are distinguished by whether or not the user has written the problem solving program. In one mode, the computer problem solving algorithms are available from some other source. The student merely provides the computer with appropriate data to use to generate a solution. A common example of this style is the frequent use of pre-existing statistical programs to generate results for a research study. This style computer problem solving requires the least amount of computer training of the user. There are many situations in school

curricula in several fields in which availability of such resources would permit students to pursue activities which otherwise would be too inefficient or too difficult. Mathematics is full of situations in which one would wish repeatedly to evaluate a particular function or formula for carefully selected values. Such activities done by hand usually require large amounts of calculation. A computer program in such cases greatly expedites the study of the behavior of a function.

The other method of using computers in problem solving is characterized by the student preparing the program that will do the work. This requires a great deal more knowledge on the part of the student. For one thing, he must be able to program the computer. Also, he must be able to create an algorithm for solving whatever problem is the focus of his concern. Hopefully, he will have some method of demonstrating that his algorithm is giving reasonable results. However, the student who successfully solves a problem this way will have significantly more knowledge of the problem and its controlling variables.

The teacher wishing to conduct problem solving exercises with pre-existing programs, must have knowledge of good sources of such programs or be able to create such programs. Many times an advanced student in the school can assist greatly with this task. The teacher must also be able to integrate instruction on the use of such programs with lessons on the topic of the problem.

The teacher wishing to entertain problem solving exercises in which the students write their own computer program must insure that the students know an adequate amount about computer programming. Perhaps this will be done in a previous course by another teacher. The present teacher still will need some extensive computer programming knowledge in order to assist in program design, preparation, and troubleshooting. Where no previous course has taught the students to program, the teacher will need not only personal programming skill, but extensive background in efficiently teaching same to others. Despite these seemingly large demands on the teacher, problem solving uses of computers are among the most frequent applications in many schools today.

Classroom Management

Every teacher has a myriad of clerical or routine activities to do that only indirectly relate to teaching. Some of these may be simplified greatly with the aid of well designed computer systems. In many of these cases, "well designed" need not mean "large" or "expensive." We mention a few of these here.

One of the activities to which teachers must pay particular attention is the keeping of inventories. Science teachers, vocational teachers, home economics teachers, and business education teachers all must keep accurate and up-to-date records of equipment and of consumable supplies. Coaches keep careful inventories of playing equipment and of individual player's performance statistics.

Each of these requires essentially the same computer program to automate. With a little planning, the science teacher, say, will make an inventory that not only will keep track of how long each consumable should last, but upon request will give out a list of those possibly in low supply, together with the address of the supplier of each in case they need to be ordered.

Another potentially powerful application of computers to schooling is in the rapidly emerging area of word processing. This style of computer use has potential application in any class in which composition is taught or course papers are written. A word processing facility automates the process of preparing and "massaging" a manuscript. This would permit students efficiently to act upon teacher critiques of a manuscript without the laborious task of recopying the entire paper.

This same facility would be efficient for teachers to make fresh, legible copies of hand-outs used year after year. The text of a hand-out would be kept in a computer file. When needed, a typewriter terminal would be loaded with a reproduction master and this year's hand-out quickly would be produced. The incidental changes required to make the hand-out current (date changes, etc.) could be made quickly through the automated editing features of a computer. To capitalize on such efficiencies requires some knowledge. What are the ingredients of an inventory program or of a word processing system? Where can such programs cheaply be obtained? How is such a system constructed, so that a teacher might direct its creation as a student project? In a later paper in this series (ISEAC No.14e) we shall present in greater detail these, and several other classroom management applications of computers.

Getting Started

In order to start instructional use of computers, one needs access to a computer. This can, and has been, achieved in many ways. This list will suggest some of the many ways that teachers have started bringing computers into a school.

1. Rent a terminal and talk a nearby university into the use of their computer.

2. Rent a terminal and talk a bank or other business into donating access to their computer.

3. The school administration already uses computers for their work and you talk them into sharing the resource with instruction.

4. A teacher agrees to write some administrative programs for the school or district if they will get the computers for both uses.

5. Talk a local business or benefactor into donating a small computer system in exchange for doing some computing jobs for the donor.

6. Talk the administration into buying a small computer in kit form. The students do the assembly and save considerable money, in addition to having a great learning experience.

7. Work in a "fairy land" school in which your administrator walks in one day and "hands you" an instructional computer.

No matter how you get started, start small and involve your students in as many ways as you can. They are probably the most valuable resource available to you for rapidly building a variety of instructional computing services.

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